

or mucoid, and that the lost capsule is the seat of the protective function in the animal body.

In recent years the concept of mutation among bacteria has entered a new stage. The studies giving origin to the advance centered about the three races of cocci associated with pneumonia in man. The pneumococcus formerly regarded as one homogeneous species was split into three distinct varieties

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when the various serological tests were systematically applied. Later the distinction among these three races was shown to be due to a carbohydrate or polysaccharide which was evidently associated with the capsule. Each race produced a different sugar which embodied the specific serological character of the race. Furthermore, each race or variety could be split into two minor races, one with the capsule, the other without it. The latter lost certain properties with the capsule, among them much of the original virulence. The so-called specificity disappeared with it, for the remaining "protein" fraction of the three races was the same. In 1928, Griffith reported an unlooked-for capacity of these three forms to become transformed one into the other following certain manipulations. Thus the capsule-deprived, so-called R form could be converted into one or another of the other S forms if dead bacteria of the desired form were injected with it into mice. In other words, the I-S form could be converted into the II-S form through the I-R stage with the help of dead II-S forms and the animal body. Later Dawson and others were able to make the transformation or conversion in the culture tube without the intermediation of the animal system. Tentatively at least, one would ascribe the capacity to become transformed to a latent capacity of the pneumococcus to form the specific substance of any one of the three races under given conditions or stimuli. Certain other bacteria, among them *B. coli*, failed to become modified under these conditions.

We must postulate for the unicellular parasites the possession of an indefinite number of capacities or *Anlagen* which enable them under suitable stimulation to develop characters and functions not recognized before. The plasticity of the disease-producing unicellular organisms leads us to the inference that all were once free-living. So far as we know, some

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saprophytes may develop into parasitic or invasive types quite readily, others may require long periods. Some may have been handed down from ancestral host types to man and the higher animals, with whose fate medicine is at present chiefly concerned.

In the adjustment of free-living saprophytic forms to a parasitic life in immediate conflict with living hosts, life cycles may require fundamental changes. Endogenous spore-formation so frequent among free-living bacteria and representing a definite cycle is not known among parasitic forms. The exception of the anthrax bacillus has been referred to and is only apparent for this bacillus is scarcely on the threshold of a parasitic existence. As pointed out by Koch, it does not form spores within the body but only after discharge in a suitable environment. Infection takes place through the ingestion of spore-containing food on pastures. The best known and widely disseminated spore-producing non-pathogenic bacterium is the so-called hay bacillus. It is a strictly aerobic type. The bacilli after the germination of the spores multiply abundantly in liquid media for about eighteen to twenty-four hours. During this period they are in active motion. Responding probably to the exhausted condition of the fluid medium they rise to the surface, become motionless, and form a thin papery pellicle. In this condition a spore is rapidly formed in each bacillus and the body of the bacillus finally undergoes autolysis. The spores settle to the bottom of the fluid awaiting transfer to fresh nutritive media for germination and a repetition of the cycle. The spore-formation requires oxygen, for when the culture is confined in a sealed space this does not take place. The anthrax bacillus has a similar cycle in nutrient media but it is not so sensitive to oxygen limitation.

The other disease-producing bacteria which sporulate—among them tetanus, malignant edema, and blackleg in cat-

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